

Text from FST Presentation Nov 15/16/2001

Can we test Quantum Gravity using Constellation-X ?

Based on ideas in DiStefano et al. astro-ph/0107001. See this paper for details glossed over below.

While there is no accepted theory for quantum gravity there are a few general assumptions we can make about properties of an eventual successful theory. The quantization of gravity will involve fluctuations in the spacetime metric. If we are observing a distant source these will cause fluctuations in the lightcone so that the arrival times of light signals will be spread about the classical prediction.

(Note that not all QG theories predict such variations in arrival times).

We cannot measure the spread in arrival times. However, we can measure one of the consequences. Consider a classical monochromatic wave from the source. The metric fluctuations will introduce a spread in the arrival times of each wave peak. This will be perceived by a detector as a spread in frequencies from the source.

So, we can search for the effects of QG on the spectra of distant sources.

Consider a source at distance r and suppose that metric fluctuations cause a mean deviation δt in propagation times. If the fluctuations are uncorrelated and a random walk type of process then we expect δt proportional to \sqrt{r} . However other dependencies are possible and require detailed calculations in a given theory.

We will assume Gaussian fluctuations with δt frequency independent. (Some theories predict frequency dependence – this can be tested using gamma-ray observations of the Crab, TeV/gamma-ray flares in blazars, and gamma-ray bursts). This implies a monochromatic source with frequency ν_0 is observed to have a spectrum with width $\nu_0^2 \delta t$.

DiStefano et al. use limits on deviations from a blackbody for the CMB spectrum to derive $\delta t < 2.1 \times 10^{-14}$ s.

Suppose we observe a 6 keV line. Then the line width will be $2 \times 10^{22} \delta t$. So determining line broadening to 1 eV would improve the current limit by about 8 orders of magnitude.

How well can we do in practice and what should we observe ?

We need sources at a reasonable distance with lines of known (small) intrinsic width or strong upper limits on their intrinsic width.

Fe K fluorescence lines from AGN ?

These are visible with Con-X to $z \sim \text{few}$. Chandra observations show a narrow component, probably from the AGN, with a velocity broadening of a few 1000 km/s \Rightarrow σ of 10s of eV.

Note that metric fluctuations \Rightarrow σ proportional to E^2 velocity broadening \Rightarrow σ proportional to E . So two lines from the same emission region would allow us to disentangle the effects.

He-line resonance lines from clusters ?

These are visible using Con-X to $z \sim 1$. They have unknown turbulent broadening - could be a few 100 km/s \Rightarrow σ of a few eV.
Could be confusion from satellite lines.

H-like lines are cleaner but weaker.

Elliptical galaxies ?

Visible using Con-X to $z \sim 0.1-0.2$. XMM-Newton observations of resonance absorption in some lines => velocity broadening must be < 40 km/s. Probably the best bet and indeed the XMM-Newton observations of NGC 4636 may already place interesting constraints.

Other suggestions ?